Laboratory Ventilation and Fume Hood Design
(Considerations for Academia)

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University of NC in Chapel Hill

- Oldest public University in US
- Founded in 1794
- 328 Buildings - over 12 M GSF
- Main campus- 809 Acres

Person Hall

- Built 1794-97
- Grew 2000 → 6000 GSF
- Uses
  - Chapel
  - Physics and Chemistry
  - School of Medicine
  - Pharmacy
  - Archeology
  - Arts
- Sustainable Building

Historic Lab Ventilation Issues

- 1886 - Chemistry Dept. Head requested cancellation of laboratory classes due to “poorly ventilated rooms”.
  - A new lab addition was promptly built

Historic Lab Ventilation Issues

- 1902- Chem. Department had expanded
  - 100 to 367 students in 16 yrs.
  - Removed ventilation hoods for student space
  - The atmosphere was foul at times

Historic Lab Ventilation Issues

- 1903- Chair of the Dept of Chemistry observes:
  - “ …students working in the qualitative laboratory with wet handkerchiefs tied about their faces to remove, in part, the poisonous vapors they must take into their lungs.”
  - Disgrace for the State of NC.

- Trustees built a new Chemistry building.

Fast Forward to 2002

- Deteriorating lab buildings
- Substandard health, and safety conditions
- Overcrowding
- Challenge of attracting/retaining quality personnel

Venable Hall-Chemistry

- Built in 1925
- Multiple additions/upgrades
- Outdated
- Replace after 80 years

Student Chem Labs

- Built 1986
- 61K GSF
- Segmented Constant volume system
- Vent. Deficiencies
  - Make up air from roof
  - Controls broke
  - System imbalanced

Consequences of Poor Design

- Poor IAQ
- Door operation problems
- $400K budgeted for repairs/balancing
- Bids were $500K
- Over budget; resources diverted

Medical Labs

- Built in 1973
- 116,344 s.f.
- HVAC repairs-$3.2 M
- Hood capacity exceeded

Consequences of Poor Design

- Demand >Design
- Long repair lead-time
- Hood use curtailed
- Restricts expansion

Existing Hoods

- Poor engineering
  - Adjacent to door/hall

Existing Hoods

- Auxiliary Air
- Poor design
- Untempered air
- Balancing issues

Historical Pattern of Laboratory Expansion

- Growth is constant
- Demand quickly outstrips facilities
- Poor design cannot be quickly remedied
- Systems degrade to critical point then trigger action

Expansion through New Construction and Renovation

- Greatest expansion in University history
- Funded through Bond Appropriations
- State in financial crisis
- Repair funds severely limited

Laboratory Growth in 10 years

- $500 Million
- 1 Million GSF
- 6 New buildings
- Major renovations

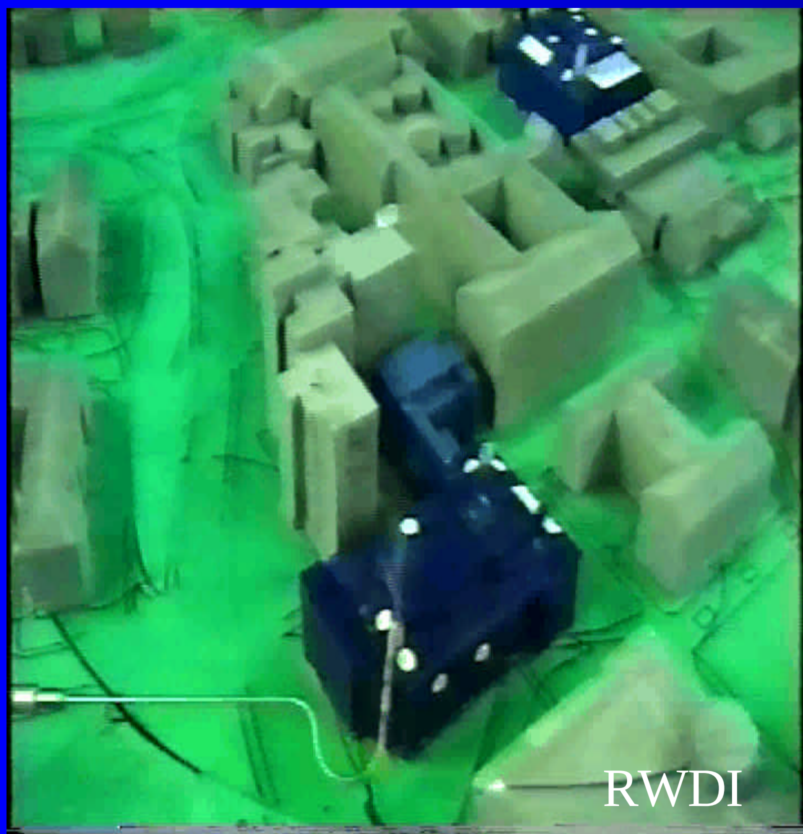
Campus Master Plan
Building Infill

- Existing-purple
- New-red
- Add 5.5 M GSF
  - Air intake protection
  - Emergency generators

Evaluating Impacts of Infill

Exhaust Dispersion Study

Science Complex



- Model buildings/topo
- Install in wind tunnel
- Discharge CO
- Visualize with smoke
- Evaluate key receptors

Exhaust Dispersion Study

Science Complex

- Combined hood exhausts
- Diesel generators
- Realistic dilution calculations

Laboratory Exhaust Hoods

- Highest energy consumer
- Critical tool for researcher protection
- Poorly understood
- Rapidly changing

Laboratory Exhaust Hoods

- Emphasis on energy savings
- Life cycle cost justification
- Hidden costs - health

Conventional vs. Low Flow

- Simple design
- Smaller footprint
- Sufficient dilution exhaust air
- VAV adaptable
- Lower cost

- Deeper
- Lower exhaust volume
- Lower energy use
- Varied complexity
- Higher initial cost
- Safer???

Low Flow Safety & Ergonomic Considerations

- Deeper hoods
  - Inability to reach back of hood
  - Head and torso into hood
- Horizontal sashes – user options
  - Full head and torso protection
  - Full body exposure

A Current Perception

"… many investigators are concerned that **"voodoo calculations"** are being used as a way to market a more expensive, less safe hood with a smaller margin of safety."

Low Flow Designs

Labcrafters
Air Sentry

Labconco
XStream

Fisher Hamilton
Pioneer &
Concept (not shown)

Kewaunee
Dynamic
Barrier LCV

Hood Selection Process

- Review literature
- Review Manufacturers data
- Talk with owners
- Develop bid specifications

Hood Selection Process

- Establish user requirements
  - Sash Type (vertical, horizontal, combo)
  - Sash openings
  - Expected use
- Consider reality (worst case)
- Determine protection levels

High Performance - Low Flow

- How **low** can you go???
  - Typically 50-60 fpm at face
  - Drafts at face
- Performance Testing
  - ASHRAE 110-95
  - ANSI/AIHA Z9.5 1992
  - Modified ASHRAE

Advances in Challenge Testing

- Obstacles in hood
- Change tracer gas
  - Volume
  - Release point
- Shorter mannequin
- Side drafts (fans)
- Walk-by simulations

High Performance - Low Flow

- Designing to the Standardized Test?
- Test Modifications $\longrightarrow$ Lower performance
  - Humans replace mannequins
  - Lower ejector heights

    (see Montana State U. studies with Hutchings/Knutsen)

Hood Engineering for Humans

- Human behavior confounds ideal hood performance
- Consider over design
- Train on proper hood use

Human Factor

- Packed hood
- Covered airfoil

Human Factor

- Hood modifications
  - Air foils removed
  - Added inner shelf
- Exhaust
  - Dampers adjusted

Human Factor

- Sash fully open
- Open waste container
- Lower airfoil removed

Human Factor

- Sash fully open
- Packed hood
- Air flow dynamics?

Science Complex Phase I Mechanical

- 10 Exhaust shafts
- 4 Exhaust heat recovery units (2 shafts/unit)
- 130 laboratory exhaust hoods
- Future capacity to add 45 hoods

Hood Selection Process (Science Complex)

- Sash Type – Combination
- Typical use
  - Vertical sash down, horizontal sashes open
  - 8 foot hoods, horizontals closed, vertical 18 in.
- Worst case
  - Vertical sash fully open
- Determine protection levels

Hood Selection Process (Science Complex)

- Evaluate as constant volume
- Set flow for restricted opening (100 fpm)
- Will maximum opening pass?
- Consider installed product performance

Hood Performance Comparison Questionnaire-2002

From: UNC-Chapel Hill--Gary Shaver 919-843-7313

Manufacturer ____

Technical Contact Name-Phone-eMail ____

Hoods to consider: 4 foot, 5 foot, 6 foot and 8 foot fume hoods, constant volume (limited bypass), combination sash
Include data for all hoods which will pass the ASHRAE standard tests in Setups 1 and 2 even if they fail in Setup 3.

Standard ASHRAE Test = ASHRAE 110-1995 with ANSI/AIHA Z9.5 1992 criteria for a Class A fume Hood

		Base Condition Setup 1						**Setup 2 (sash only adjustment)**		
Hood Model (Name and Number)	Exterior Hood Dimensions	Opening size-(vertical sash down, max number of horizontal panels open) sq.ft.	Face Velocity (fpm)	Exhaust volume (cfm)	Passes Standard Ashrae test?*		Passes Modified Ashrae test?#	…g size-(vertical sash op… …d all horizontal pane… …sq. ft.	Face Velocity (fpm)	Exhaust volume (cfm)
					AM	AI				

AM=as manufactured AI=as installed

* Provide all supporting in-factory and in-field (as installed) testing data that demonstrates this hood performance.

A **Modified ASHRAE** test can take many forms including: Lowering the mannequin height, increasing HS6 emission rates, adding boxes into the hood, crea
Provide a detailed description of your modifications to the ASHRAE test if available, what they demonstrate about actual installed conditions and which of your

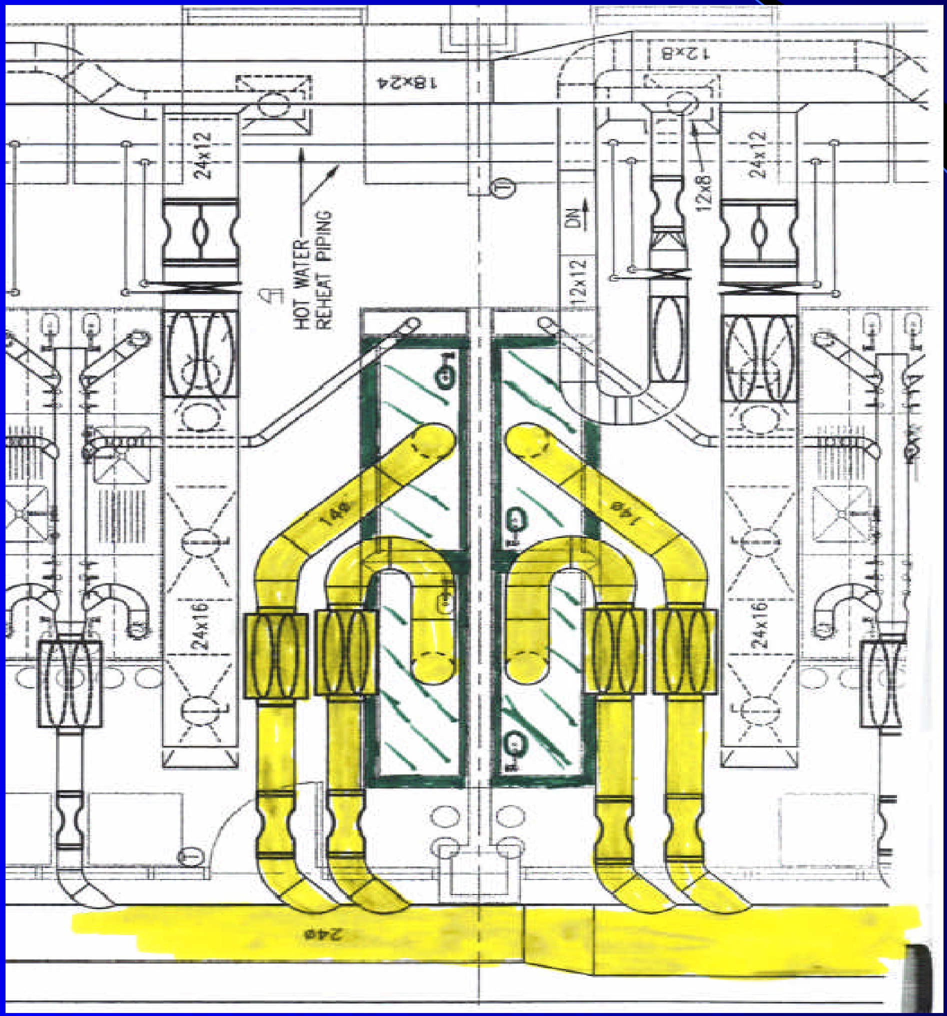
Names and Contacts for other large research institutions using each of the proposed hood models.

Hood Model (Name/number)	**Institution**	**Contact Person**	**Phone #**	**eMail**

Summary of Findings

- Advanced hoods reported to:
  - Meet ANSI/AIHA test criteria AM (AI)
    - Horizontal sash open, vertical down
    - Vertical sash 18 inches, horizontal closed
  - Pass/fail at full open sash
  - Use standard and modified ASHRAE 110
  - Installed base limited

Science Complex Hood Exhaust with VAV



Science Complex Hood Exhaust with VAV

- Noise attenuators – dust and debris
- Static pressure losses
- Balancing issues
- Mechanical complexity
- User dependent

VAV Considerations

- All VAVs are not equal in performance
- Diversity may not match design
- Expensive

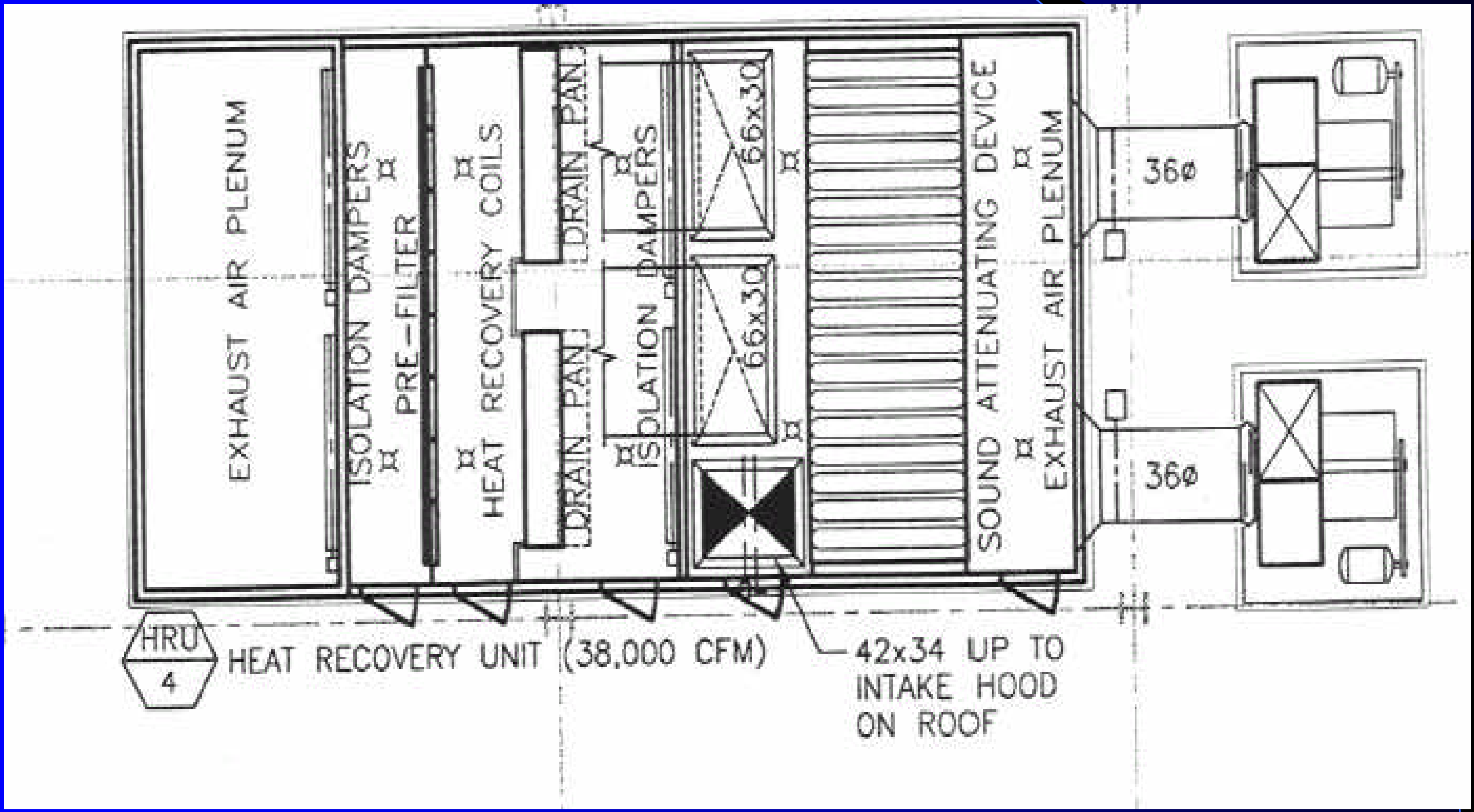
VAV Considerations

- Payback not always realized
- Commissioning critical
- Some Universities disallow VAV systems

Combined Exhaust (Minimize Stacks)

- Increase Dilution
- Reduce maintenance
- Energy recovery
- Emergency power
- Fan Redundancy (50%)

Combined Exhaust with Energy Recovery



IMC Section 510 Challenge

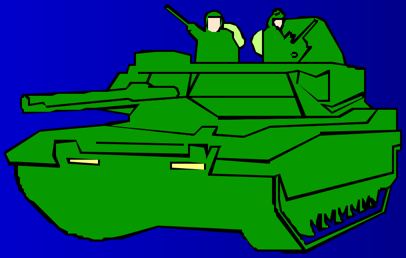
- Defines hazardous exhaust
- Limits combined exhaust (separate general exhaust)
- Prohibits incompatible mixing
- Fire suppression in duct systems
- Ignores small quantities/high dilutions

IMC Section 510 Challenge

- Alternate M&M
  - NFPA 45 Chapter 6
  - ANSI/AIHA Z9.2 (in revision)
- AIHA Lab Safety Committee position paper
- Code change process in progress (2 yrs)
- Intent - exclude laboratories

Bidding Wars

- Specifications
  - Incorporate recognized standards
  - Qualifies 3 bidders
  - Precludes bid challenges
    - Long construction delays
- Low bid wins but not necessarily the best!



Lessons Learned on Lab Ventilation

- Keep it simple
- Minimize mechanical parts
- Minimize maintenance
- Maximize flexibility for growth

Lessons Learned on Lab Ventilation

- Hood selection defines
  - Space
  - Mechanical systems
- Hood design is in continuous flux
- Selection impacts next 30+ years
- Maximize safety

Laboratory Exhaust Systems

- High stakes
  - Safety
  - Health
  - Energy
- High first costs
- High operating costs (heating/cooling)
- Incomplete performance picture
- High emotions

In Academia:
Learn from a rich past
Prepare for the distant future
and ....

Keep your Cool!

Existing Hoods

- Hood conversions
  - Block supply
  - Convert sash to bulletin board